

Appl. No. 10/573,339
Amdt. Dated March 23, 2009
Reply to Office Action of October 21, 2008

Attorney Docket No. 81880.0144
Customer No.: 26021

Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

1.-29. (Cancelled)

30. (Withdrawn) A multi-layer piezoelectric device comprising: a stack formed by stacking piezoelectric layers and internal electrodes alternately one on another; and external electrodes formed on a first side face and on a second side face of the stack,

wherein one of the adjacent internal electrodes is connected to the external electrode formed on the first side face and the other internal electrode being connected to the external electrode formed on the second side face;

wherein a content of an alkali metal is not less than 5 ppm nor more than 300 ppm.

31. (Withdrawn) The multi-layer piezoelectric device according to claim 30;

wherein the piezoelectric layers include the alkali metal of not less than 5 ppm nor more than 500 ppm.

32. (Withdrawn) The multi-layer piezoelectric device according to claim 30;

wherein the internal electrodes include the alkali metal of not less than 5 ppm nor more than 500 ppm.

33. (Withdrawn) The multi-layer piezoelectric device according to claim 30;

wherein the external electrodes include the alkali metal of not less

than 5 ppm nor more than 500 ppm.

34. (Withdrawn) The multi-layer piezoelectric device according to claim 30; wherein the alkali metal is at least one kind of Na and K.

35. (Withdrawn) The multi-layer piezoelectric device according to claim 30; further comprising a halogen element of not less than 5 ppm nor more than 1000 ppm.

36. (Withdrawn) A multi-layer piezoelectric device comprising: a stack formed by stacking piezoelectric layers and internal electrodes alternately one on another; and external electrodes formed on a first side face and on a second side face of the stack,

wherein one of the adjacent internal electrodes is connected to the external electrode formed on the first side face and the other internal electrode being connected to the external electrode formed on the second side face;

wherein a content of a halogen element content is not less than 5 ppm nor more than 1000 ppm.

37. (Withdrawn) The multi-layer piezoelectric device according to claim 36; wherein the piezoelectric layers include the halogen element of not less than 5 ppm nor more than 1500 ppm.

38. (Withdrawn) The multi-layer piezoelectric device according to claim 36; wherein the internal electrodes include the halogen element of not less than 5 ppm nor more than 1500 ppm.

39. (Withdrawn) The multi-layer piezoelectric device according to claim 36; wherein the external electrodes include the halogen element of not less than 5 ppm nor more than 1500 ppm.

40. (Withdrawn) The multi-layer piezoelectric device according to claim 36; wherein the halogen element is at least one kind of Cl and Br.

41. (Withdrawn) A multi-layer piezoelectric device comprising: a stack formed by stacking piezoelectric layers and internal electrodes alternately one on another; and external electrodes formed on a first side face and on a second side face of the stack,

wherein one of the adjacent internal electrodes is connected to the external electrode formed on the first side face and the other internal electrode being connected to the external electrode formed on the second side face;

wherein a ratio of change in the device dimension after undergoing 1×10^9 cycles of continuous operation to the initial device dimension is not larger than 1%.

42. (Withdrawn) The multi-layer piezoelectric device according to claim 41; wherein a ratio of change in thickness of the internal electrode after undergoing 1×10^9 cycles of continuous operation to the initial thickness of the internal electrode is not larger than 5%.

43. (Withdrawn) The multi-layer piezoelectric device according to claim 30; wherein an inorganic component is added along with the metallic component in the internal electrode.

44. (Withdrawn) The multi-layer piezoelectric device according to claim 43; wherein the inorganic component contains perovskite type oxide consisting of PbZrO₃-PbTiO₃ as the main component.

45. (Withdrawn) The multi-layer piezoelectric device according to claim 30; wherein the piezoelectric layer contains perovskite type oxide as the main component.

46. (Withdrawn) The multi-layer piezoelectric device according to claim 45; wherein the piezoelectric layer contains perovskite type oxide consisting of PbZrO₃-PbTiO₃ as the main component.

47. (Withdrawn) The multi-layer piezoelectric device according to claim 30; wherein firing temperature of the stack is not less than 900 nor more than 1000°C.

48. (Withdrawn) The multi-layer piezoelectric device according to claim 30; wherein a deviation in the composition of the internal electrode that is caused by the firing is not more than 5%.

49. (Currently Amended) A multi-layer piezoelectric device made by stacking piezoelectric layers and internal electrodes alternately one on another, wherein the piezoelectric layer contains PbTiO₃-PbZrO₃ as a main component and contains Si of not less than 5 ppm nor more and less than 100 ppm;
wherein the grain boundary has single molecules of SiO₂ and has no glass phase containing SiO₂.

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50. (Previously Presented) The multi-layer piezoelectric device according to claim 49; wherein Si is segregated in the crystal grain boundary and thickness of the grain boundary is not larger than 1 nm.

51. (Withdrawn) The multi-layer piezoelectric device according to claim 30; wherein the metal compound in the internal electrode contains group VIII metal and/or group Ib metal as the main components.

52. (Withdrawn) The multi-layer piezoelectric device according to claim 51; wherein a proportion M1 (% by weight) of the group VIII metal and a proportion M2 (% by weight) of the group Ib metal in the internal electrode satisfy relations $0 < M1 \leq 15$, $85 \leq M2 < 100$ and $M1 + M2 = 100$.

53. (Withdrawn) The multi-layer piezoelectric device according to claim 51; wherein the group VIII metal is at least one kind selected from a group consisting of Ni, Pt, Pd, Rh, Ir, Ru and Os, and the group Ib metal is at least one kind selected from a group consisting of Cu, Ag and Au.

54. (Withdrawn) The multi-layer piezoelectric device according to claim 51; wherein the group VIII metal is at least one kind selected from a group consisting of Pt and Pd, and the group Ib metal is at least one kind selected from a group consisting of Ag and Au.

55. (Withdrawn) The multi-layer piezoelectric device according to claim 51; wherein the group Ib metal is Cu.

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56. (Withdrawn) The multi-layer piezoelectric device according to claim 51; wherein the group VIII metal is Ni.

57. (Withdrawn) The multi-layer piezoelectric device according to claim 30; wherein the internal electrode includes voids and the voids occupy 5 to 70% of cross sectional area of the internal electrode.

58. (Withdrawn) The multi-layer piezoelectric device according to claim 30; wherein a groove is formed between the end of the other internal electrode and the external electrode on the first side face, with the groove being filled with an insulating material and a groove is formed between the end of the one internal electrode and the external electrode on the second side face, with the groove being filled with an insulating material, the insulating material having Young's modulus lower than that of the piezoelectric layer.

59. (Withdrawn) The multi-layer piezoelectric device according to claim 36; wherein an inorganic component is added along with the metallic component in the internal electrode.

60. (Withdrawn) The multi-layer piezoelectric device according to claim 41; wherein an inorganic component is added along with the metallic component in the internal electrode.

61. (Withdrawn) The multi-layer piezoelectric device according to claim 36; wherein firing temperature of the stack is not less than 900 nor more than 1000°C.

62. (Withdrawn) The multi-layer piezoelectric device according to claim 41; wherein firing temperature of the stack is not less than 900 nor more than 1000°C.

63. (Withdrawn) The multi-layer piezoelectric device according to claim 36; wherein a deviation in the composition of the internal electrode that is caused by the firing is not more than 5%.

64. (Withdrawn) The multi-layer piezoelectric device according to claim 41; wherein a deviation in the composition of the internal electrode that is caused by the firing is not more than 5%.

65. (Withdrawn) The multi-layer piezoelectric device according to claim 36; wherein the internal electrode includes voids and the voids occupy 5 to 70% of cross sectional area of the internal electrode.

66. (Withdrawn) The multi-layer piezoelectric device according to claim 41; wherein the internal electrode includes voids and the voids occupy 5 to 70% of cross sectional area of the internal electrode.

67. (Withdrawn) The multi-layer piezoelectric device according to claim 36; wherein a groove is formed between the end of the other internal electrode and the external electrode on the first side face, with the groove being filled with an insulating material and a groove is formed between the end of the one internal electrode and the external electrode on the second side face, with the groove being filled with an insulating material, the insulating material having Young's modulus lower than that of the piezoelectric layer.

68. (Withdrawn) The multi-layer piezoelectric device according to claim 41; wherein a groove is formed between the end of the other internal electrode and the external electrode on the first side face, with the groove being filled with an insulating material and a groove is formed between the end of the one internal electrode and the external electrode on the second side face, with the groove being filled with an insulating material, the insulating material having Young's modulus lower than that of the piezoelectric layer.

69. (Withdrawn) A multi-layer piezoelectric device comprising: a stack formed by stacking piezoelectric layers which include the alkali metal of not less than 5 ppm nor more than 500 ppm and internal electrodes alternately one on another; and external electrodes formed on a first side face and on a second side face of the stack,

wherein one of the adjacent internal electrodes is connected to the external electrode formed on the first side face and the other internal electrode being connected to the external electrode formed on the second side face;

wherein a content of an alkali metal is not less than 5 ppm nor more than 300 ppm.

70. (Withdrawn) A multi-layer piezoelectric device comprising: a stack formed by stacking piezoelectric layers and internal electrodes which include the alkali metal of not less than 5 ppm nor more than 500 ppm alternately one on another; and external electrodes formed on a first side face and on a second side face of the stack,

wherein one of the adjacent internal electrodes is connected to the external electrode formed on the first side face and the other internal electrode being

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connected to the external electrode formed on the second side face;
wherein a content of an alkali metal is not less than 5 ppm nor more than 300 ppm.

71. (Withdrawn) A multi-layer piezoelectric device comprising: a stack formed by stacking piezoelectric layers and internal electrodes alternately one on another; and external electrodes formed on a first side face and on a second side face of the stack,

wherein the external electrodes include the alkali metal of not less than 5 ppm nor more than 500 ppm and one of the adjacent internal electrodes is connected to the external electrode formed on the first side face and the other internal electrode being connected to the external electrode formed on the second side face;

wherein a content of an alkali metal
is not less than 5 ppm nor more than 300 ppm.